

REMARKS

Favorable consideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 1-18 are pending in the application, with Claim 1 having been amended by way of the present amendment.

In the outstanding Office Action, Claims 1 and 8 were rejected under 35 U.S.C. § 102(e) as being anticipated by Oh et al. (U.S. Patent No. 6,200,903, hereinafter Oh); Claim 1 was rejected under 35 U.S.C. § 102(b) as being anticipated by Kobayashi (JP 4127518A); Claims 2 and 4 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Oh, and further in view of Applicants' admitted prior art; Claims 2-4 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Oh or Kobayashi, and further in view of Bell (U.S. Patent No. 5,767,018); Claims 9 and 10 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Oh, and further in view of Geusic et al. (U.S. Patent No. 6,518,615, hereinafter Geusic); Claim 11 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Oh and Geusic, and further in view of Borodovsky (U.S. Patent No. 4,529,685); Claims 5, 6, 12, and 13 were indicated as allowable; and Claims 14-18 were allowed.

Applicants gratefully acknowledge the indication of the allowable subject matter.

Independent Claim 1 has been amended to recite that the first resist pattern includes a predetermined first thickness and that the curing/ion implantation is controlled so that the predetermined first thickness contracts to a second predetermined thickness. Support for this amendment is found in Applicants' originally filed specification.¹ No new matter is added.

Briefly recapitulating, amended independent Claim 1 is directed to a method of manufacturing a semiconductor device, comprising steps of: (a) forming an etching object on a semiconductor substrate; (b) forming a first resist film having a first predetermined

thickness on said etching object; and (c) patterning said first resist film to obtain a first resist pattern. These steps are followed by (d) performing ion implantation into said first resist pattern with a predetermined ion implantation level set so that the first predetermined thickness contracts to a second predetermined thickness; and (e) executing predetermined etching on said etching object using said first resist pattern as a mask to obtain a work pattern, after execution of said steps (c) and (d). The first predetermined pattern thickness and the predetermined ion implantation level are each set so the second predetermined thickness corresponds to a predetermined critical dimension shift in said work pattern. Critical dimension shift is a phenomenon that varies with the density of the etching.² By controlling the critical dimension shift in patterns with both high and low density portions, precise pattern etching of high density patterns is more easily achieved.³

Oh is directed to a method of manufacturing a semiconductor device where a first photoresist pattern is hardened by argon implantation, where the tilt angle of argon implantation is controlled to prevent or minimize thickness contraction.⁴ This process allows for thinner and harder first resist patterns, thus allowing second photoresist patterns to be applied more easily and without breakage of the first photoresist pattern.⁵ Oh does not, however, teach or disclose setting both a first predetermined resist pattern thickness and a predetermined ion implantation level to produce a second predetermined resist thickness as recited in amended Claim 1.

Furthermore, Oh does not teach or suggest setting the first predetermined thickness and ion implantation level to produce a second predetermined thickness corresponding to a critical dimension shift. In Oh, the thickness of the first resist pattern is 650 nm (or 6500 Å).

¹ Specification, page 18, line 25 – page 19, line 7; page 19, lines 20-25.

² Specification, page 2, lines 17-22.

³ Specification, page 6, lines 3-11.

⁴ Oh, column 3, lines 24-44, Figure 6.

By ion implantation the resist thickness is reduced by 30% - 40% from the conventional case.

From these two points of the disclosure, the calculated thickness of the first resist pattern is 390-455 nm. On the other hand, the present invention, as shown in Fig. 12, shows the first resist pattern with the thickness of 344 nm as the thickness which corresponds to the predetermined difference in critical dimension shift in the work pattern (the thickness which is less than the predetermined reference value at 0.059 μ m of crude density difference in critical dimension shift in the resist pattern). Therefore, the thickness of 390-455 nm of the first resist pattern after the ion implantation calculated from Oh's disclosure does not suggest the second predetermined thickness of the Claim 1, which is the thickness that corresponds to the predetermined difference in critical dimension shift in the work pattern. Oh does not suggest even indirectly that the first predetermined thickness and the level of ion implantation are set so that the second predetermined thickness corresponds to the predetermined difference in critical dimension shift in the work pattern, as recited in Claim 1.

Applicants therefore submit Oh does not teach or suggest all the features recited in amended Claim 1 and, thus, the inventions defined by independent Claim 1, and all claims depending therefrom, are not rendered obvious by the asserted prior art for at least the reasons stated above.⁶

In addition, Applicants note Oh does not mention the phenomenon of critical dimension shift. Thus, Applicants submit there is no teaching, suggestion, or motivation, either explicitly or implicitly, in Oh to modify the oblique ion implantation process of Oh to arrive at Applicants' inventions recited in Claim 1. Thus, Applicants submit it is only

⁵ Oh, column 4, lines 21-28.

⁶ MPEP § 2142 "...the prior art reference (or references when combined) must teach or suggest **all** the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991)."

through an impermissible hindsight reconstruction of Applicants' invention that the rejection of Claim 1 can be understood.⁷

Kobayashi teaches boron implantation to controllably contract a first resist film thickness.⁸ However, like Oh, Kobayashi does not teach or suggest setting the first predetermined thickness and ion implantation level to produce a second predetermined thickness corresponding to a critical dimension shift. Further, in the second embodiment of Kobayashi, the thickness after boron ion implantation is 0.45 μm (450 nm) and, therefore, suffers from the same deficiencies as identified previously for Oh. Thus, Applicants submit that Kobayashi does not anticipate or render obvious the present invention for at least the reasons cited above.

Regarding the rejection of Claims 2 and 4, Applicants traverse the finding in the Official Action that "forming insulating film including silicon nitride is requisite in the conventional etching of the wiring pattern forming method as described in page 3, line 13, of the specification." Applicants disclosed conventional art only teaches silicon nitride as an example of an insulating film to insulate metal wiring and so on. On the other hand, Applicants Claim 2 clearly recites that the ion prevention film prevents ions implanted in step (d) from being implanted into the actual etching object, and the ion prevention film is set for the purpose to prevent the ion implantation to the actual etching object. Therefore, the conventional use of a silicon nitride film for insulation does not rise to the level of a teaching or suggestion of forming a silicon nitride film on an actual etching object as an ion implantation prevention film. In addition, the anti-reflective coating disclosed by Applicants' disclosed prior art of Bell is a film mounted to prevent the desensitization by the reflection of

⁷ MPEP § 2143.01 "Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge of one of ordinary skill in the art."

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the light, and is not mounted to prevent ion implantation as recited in Applicants' Claim 2. Hence, Applicants request the pending rejection of Claims 2 and 4 be withdrawn as both Applicants' disclosed prior art and Oh fail to teach or suggest the recited features of Claim 2.

Applicants have also considered the Bell, Geusic, and Borodovsky and submit that these references do not cure the above-described deficiencies of Oh or Kobayashi.

Accordingly, in view of the present amendment and in light of the previous discussion, Applicants respectfully submit that the present application is in condition for allowance and respectfully request an early and favorable action to that effect.

Respectfully submitted,

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⁸ Kobayashi, page 6, line 15 – page 7, line 5.